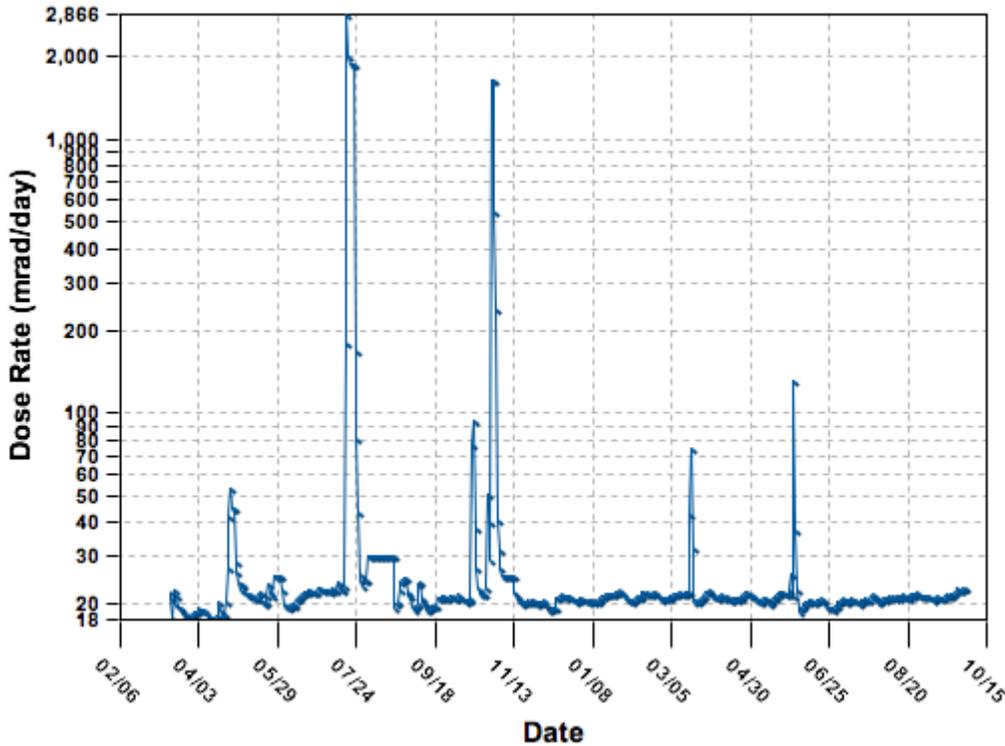


Calculating Total Radiation Dosages at Mars

MARIE Daily Average Dose Rates: 03/13/2002 - 09/30/2003



The NASA, Mars Radiation Environment Experiment (MARIE) measured the daily radiation dosages from a satellite orbiting Mars between March 13, 2002 and September 30, 2003 as shown in the figure above. The dose rate is given in units of milliRads per day. (1 Rad = 2 Rems for cosmic radiation.) The six tall 'spikes' are Solar Proton Events (SPEs) which are related to solar flares, while the rest of the plotted data (the wiggly line!) is the dosage caused by galactic cosmic rays (GCRs).

1. By finding the approximate area under the plotted data, calculate the total radiation dosage in Rems for the GCRs during the observation period between 4/03/2002 and 8/20/2003.
2. Assuming that each SPE event lasted 3 days, and that its plotted profile is a simple rectangle, calculate the total radiation dosage in Rems for the SPEs during the observation period.
3. What would be the total radiation dosage for an unshielded astronaut orbiting Mars under these conditions?
4. Are SPEs more important than GCRs as a source of radiation? Explain why or why not in terms of estimation uncertainties that were used.

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Teachers Note: Because students will be asked to determine the areas under a complicated curve using rectangles, please allow student answers to vary from the below estimates, by reasonable amounts! This may be a great time to emphasize that, sometimes, two scientists can get different answers to the same problem depending on how they do their calculation. Averaging together the student responses to each answer may be a good idea to improve accuracy!

1. By finding the approximate area under the plotted data, calculate the total radiation dosage in Rems for the GCRs during the observation period between 4/03/2002 and 8/20/2003.

From the graph, the average dosage rate is about 20 mRads/day. The time span is about $365 + 4 \times 30 + 17 = 502$ days. The area of a rectangle with a height of 20 milliRads/day and a width of 502 days is $(20 \text{ milliRads/day}) \times (502 \text{ days}) = 10040$ milliRads. This can be converted to Rems by multiplying by $(1 \text{ Rad}/1000 \text{ milliRads})$ and by $(2 \text{ Rem}/1 \text{ Rad})$ to get **20 Rems**.

2. Assuming that each SPE event lasted 3 days, and that its plotted profile is a simple rectangle, calculate the total radiation dosage in Rems for the SPEs during the observation period.

Peak 1 = 53 milliRads/day x 3 days = 159 millirads

Peak 2 = 2866 millirads/day x 3 days = 8598 milliRads

Peak 3 = 90 milliRads/day x 3 days = 270 milliRads

Peak 4 = 1700 milliRads/day x 3 days = 5100 milliRads

Peak 5 = 70 milliRads/day x 3 days = 210 milliRads

Peak 6 = 140 milliRads/day x 3 days = 420 milliRads

The total dosage is 14,757 milliRads.

Convert this to Rems by multiplying by $(1 \text{ Rad}/1000 \text{ milliRads}) \times (2 \text{ Rem}/1 \text{ Rad})$

To get **30 Rems after rounding**.

3. What would be the total radiation dosage for an unshielded astronaut orbiting Mars under these conditions?

Answer: 20 Rems + 30 Rems = **50 Rems** for a 502-day visit.

4. Are SPEs more important than GCRs as a source of radiation? Explain why or why not.

Answer: Solar Proton Events may be slightly more important than Galactic Cosmic Radiation for astronauts orbiting Mars.

The biggest uncertainty is in the SPE dose estimate. We had to approximate the duration of each SPE by a rectangular box with a duration of exactly three days, although the plot clearly showed that the durations varied from SPE to SPE. If the average dose rate for each SPE were used, rather than the peak, and a shorter duration of 1-day were also employed, the estimate for the SPE total dosage would be significantly lower, perhaps by as much as a factor of 5, from the above estimates, which would make the GCR contribution, by far, the largest.